Kondratieff cycles in the pre-industrial period: a statistical investigation

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"There is a tide in the affairs of men" (Shakespeare)

KONDRATIEFF CYCLES IN THE PRE-INDUSTRIAL PERIOD: A STATISTICAL INVESTIGATION(1)

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Abstract: In this study, an attempt has been made to identify Kondratieff cycles in the pre-industrial period by analysing non-price time series. For the elimination of statistically distorted series, a new approach was used: The individual series were subjected to Box-Jenkins-Analysis and series with an implausible structure were rejected. From the remaining series the trend was eliminated by means of polynomials. The moving averages of the residuals show a Kondratieff type oscillation. The Length of the individual cycles is about 40 to 45 years, which is somewhat shorter than the length of the Kondratieff cycles of the nineteenth and twentieth century.

A. INTRODUCTION TO THE PROBLEM AND THE METHODS

Since its discovery in the 1920s the 50 to 60 year Kondratieff cycle has been the subject of much controversy. It appears to be generally acknowledged that the swings N.D. Kondratieff identified when examining data from the 1780 to 1920 period (Kontratieff 1926) actually took place and that economic events after 1920 followed the same pattern; yet many economists dispute the existence of a 50 to 60 year cycle and regard the observed swings as random deviations from the growth path and the relative similiarity of the length of these fluctuations as a mere coincidence. Nor is this surprising: The time span from 1780 to the present time contains just about four periods of the cycle, which is not sufficient to rule out randomness.

The logical step to take is therefore to investigate whether Kondratieff cycles can also be identified in the pre-industrial period, as for instance Schumpeter supposed (Schumpeter 1961, Chap.VI). Doing so, however, is no easy matter,since the number of time series from this period is considerably below what is available for the 19th and 20th centuries. In addition, most of the existing time series are price series, the interpretation of which is still debated(2) and which therefore are of limited value as economic indicators. It thus is not surprising that as yet little work has been done in this field(3).

This study constitutes an attempt to identify Kondratieff cycles in the period from 1550 to about 1800, using only non-price series. The original notion had been to make use of a modern statistical tool specifically designed for the identification of cyclical processes, like spectral analysis or the SARIMA-processes of Box-Jenkins-Analysis. Unfortunately, this turned out to be impossible: If a time series or a part of a time series is analysed with either of these methods, the part to be analysed may not contain any missing values, but on the other hand should be long enough to contain

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at least three cycles, i.e. at least 150 years. Now apart from price series very few pre-industrial time series exist, which in the course of 150 years do not contain a single missing value; consequently this attempt had to be abandoned.

I thus was forced to use the same method used by N.D. Kondratieff, namely, trend removal by polynomial regression. Usually, a third degree polynomial was fitted to the time series, if necessary after appropriate transformations to achieve homoskedasticity. If the t-value of the parameters of the third degree polynomial was less than about two, a lower degree polynomial was used. Afterwards, moving averages of the residuals were calculated to remove the influences of both the short business cycles and short-term random disturbances. N.D. Kondratieff had used a nine year moving average, based on a Juglar cycle of 7-11 years (Kondratieff 1926, p. 577). The Box-Jenkins-Analysis of the time series used in this study showed that in the pre-industrial period the duration of a Juglar cycle was considerably shorter, namely only about 5-6 years. This would have indicated the use of a five year moving average, which, however, would have been rather short and might not have been sufficient to neutralize larger random fluctuations. Therefore an eleven year moving average was used, corresponding to two Juglar cycles. If one or more values were missing, a moving average of the remaining values was computed, as long as no more than five of the eleven values were missing.

Now the combination of a high-pass filter (like a polynomial) and a low-pass filter (like moving averages) is bound to result in oscillations in the middle range. It is not possible to calculate the exact effects of this combination because there is no way to determine the transfer function of a polynomial. Because of this it cannot be said whether a given 50 year oscillation in the moving averages of the residuals has only been made visible by this combination or whether it actually has been induced by it, as long as only a single time series is observed. Due to this, a cycle can be considered as identified only if this procedure results in approximately the same peaks and troughs for various time series. These time series ought to be about different fields and from different countries, because similiar time series can be expected also to have similiar transfer functions of the polynomials.

The problem here is that even if a cycle actually exists, one cannot expect all the series to show more or less identical peaks and troughs for two reasons:

a) The development of production or sales of certain commodities simply may not be representative for the development of the economy as a whole. During the Thirty Years War, shipments of flax, flaxseed, hemp and the like registered at the toll stations in the Öresound increased even at a time when shipments of other commodities showed a decline, probably on account of wartime demand for textiles.

b) Even if the development of, say, the production of a given commodity moved synchronous with the development of the whole economy, the quality of the statistical registration of the production may have varied. In such a situation, registered production may have risen due to better registration, even if actual production remained constant or even declinded.

If a large number of time series are available, this is not much of a problem: a cycle is then considered as identified if most of the series show the same peaks and troughs. It is this kind of analysis which was made by N.D. Kondratieff.

Unfortunately, when working with pre-industrial data, the number of available time series is not large, and it therefore is not possible to eliminate distorted or non-representative time series this way, so I had to identify these series by some other means. In the case of those series, which were not representative on account of wars or other special influences, this usually was not particularly difficult: Since all series were taken from secondary sources, one had a context in which such influences were usually pointed out.

Distortions due to statistical influences were more of a problem. Here again, much could be found in the literature, but statistical defects usually are not obvious and therefore not necessarily known. In addition, it is not a question of whether a time series is defective or not - one simply is forced to work with data which are known to be defective: Almost all pre-industrial time series are based on customs or tax data, and of course there was a premium on underreporting. The question rather is whether the defect is serious enough to render the series useless for the purposes of this study. This question usually cannot be answered from the existing literature.

I therefore used Box-Jenkins-Analysis as a tool to determine whether the structure of a time series or of parts of a time series was plausible or not. Since the Box-Jenkins-Analysis has to my knowledge never been used previously for this purpose, no known structures were available for comparison; due to this, my decision ultimately had to depend on subjective judgement. Nevertheless the results obtained appear to be quite good: I have so far followed up two of the cases in which a time series was rejected solely on statistical grounds, and in both cases the cause of the distortion could be found.

The time series themselves were not selected by any systematic criteria, other than that no price series were used and that the subject of the series had to be of more than merely local importance: Since no generally accepted theoretical explanation of the Kondratieff cycle exists, there also exist no criteria by which to decide which time series are particularly important when trying to identify a Kondratieff cycle.

B. PRESENTATION AND ANALYSIS OF THE TIME SERIES

I. time series 1 to 6: transports of commodities through the Sound

The first six time series are based on customs data collected in the Öresound between 1562 and 1853. Since the duty was not an ad valorem duty, but a specific duty on the various commodities transported, it is possible to learn from the toll registers which amounts of which goods were transported in the various years. In the time between 1906 and 1953 the toll registers of the 1562-1783 period were edited and published as tables first by the Danish historian Nina Ellinger Bang and after her death by her successor Knud Korst (Ellinger Bang/Korst 1906-1953). The time series used in this study were taken from the volumes 3,5,6 and 7 of the tables, which are ordered by commodities.

The Sound Toll Registers are an important historical source, since almost the entire exchange between the Baltic and West Europe passed through the

Sound. Most of the goods traded were too bulky for transport on land (Jeannin 1964, p. 59), and use of the other straits between the Baltic and the Kattegat was forbidden to all ships except those of nations which were exempt from duty anyway (Christensen 1934, p. 59-69). In the case of exports from Poland and eastern Germany, the Sound toll could be avoided by using the Elbe, particularly after the Oder-Spree-canal was finished in 1668 (Herder-Gersdorff 1978, p. 111 and 125), and in the case of trade with Russia Archangelsk could be used (Jeannin 1964, p. 59); yet both alternative routes were not very important.

Unfortunately, goods belonging to merchants of exempt nations (Denmark, Norway and, until 1720, Sweden) were not registered in the Sound. In the case of Danish and Norwegian goods this generally is not much of a problem and may actually have the advantage of eliminating the merely local and regional traffic, which is less interesting for conjuncture analysis. The non-registration of Swedish goods, however, is a serious defect, particularly for the period between 1660 and 1710 (4), during which some 30 to 40 percent of all goods passing the Sound were not declared (Jeannin 1964, p. 310). Owing to this, little can be learned from the time series concerning the transport of goods either produced in the then Sweden (like flaxseed produced around Riga) or produced in Russia and transported via Swedish harbours at the Baltic. In order to identify the series seriously affected by this factor, a Box-Jenkins intervention analysis was used. Since almost all time series show a rise of the figures after 1720, owing to the end of the Nordic War, two dummy variables were used, one for the influence of the Nordic War and one for the effects of non-declaration. In the case of some series a significant effect of the non-declaration could be established. These series were not used in the study.

Another problem was the smuggling of goods. From 1618 onwards, ships were routinely searched, which method reduced smuggling to a negliable amount of ten percent and less (Christensen 1941, p. 350 and 358). Prior to 1618, however, controls were insufficient and smuggling therefore intensive, amounting at times to 40-50 percent (Jeannin 1964, p. 100). The percentage figures refer to the customs duty which, without smuggling, would have been paid. In principle, this duty was based on the value of the various commodities. If transported goods were aggregated by weight, the share of smuggled goods would be considerably lower, since it was mainly goods with a high value per weight unit which were smuggled (Christensen 1934, p. 124).

Again, use was made of the Box-Jenkins-Analysis to identify those series which in the time before 1618 were seriously distorted by the effects of smuggling. Since it is only the first quarter of the series which was affected by smuggling, these series were nevertheless used in this study, but no value was attached to their pre-1618 peaks and troughs.

Had these series been excluded, very few series would have remained. As it is, the tables edited by Ellinger Bang and Korst begin with data about transports of 38 different commodities. 21 of these time series are continuous from 1562 to 1783. Of these, the following had to be eliminated:

- wool and cloth transported westward, because the amounts involved were negligible
- ash, pitch and tar, flax and hemp, colonial goods, "other fish" (than herring) and "other wines" (than Rhine wine), because here different goods were lumped together, although the goods involved are more or less inhomogenous (in the extreme case of colonial goods pepper, rice, sugar, indigo and tabacco were summed up by their weights).

- Rhine wine on account of a break in the statistics; from 1721 onwards the wines from Rhine and Moselle were registerd together.

In the course of the analysis of the remaining series, flaxseed and skins, furs and leathers were excluded on account of a significant effect of the non-declaration of Swedish goods. Thus only six series about the transport of rye, wheat, salt, herring (all in lasts), wax (in shippounds) and eastward bound cloth (in pieces) remained.(5) Among these, however, are the most important goods of the east-west exchange, namely rye, salt and herring.

The series cover the period from 1562 to 1783, with the exeption of the years 1570-73, 1632, 1634, 1650-53 and 1658-60, for which the data are either missing or incomplete. In addition, the atypical year 1645 was left out of the calculation since it is obviously distorted by the Danish-Swedish war of that year. To the other values a polynomial was fitted. In the case of five of the series, the parameters of a third degree polynomial were significant. These polynomials had the following forms:

for rye: $y = -133{,}701{,}610 + 240{,}517.5\ x - 143.99509\ x^2 + 0.0286698184\ x^3$

for wheat: $y = -55{,}120{,}914 + 99{,}172.579\ x - 59.445768\ x^2 + 0.011873498\ x^3$

for salt: $y = -38{,}325{,}397 + 70{,}300.443\ x - 42.924526\ x^2 + 0.0087299624 x^3$

for herring: $y = -50{,}659{,}118 + 91{,}185.424\ x - 54.659283\ x^2 + 0.01912381\ x^3$

for cloth: $y = -246.742.360 + 441{,}810.9\ x - 263.51275\ x^2 + 0.052362899\ x^3$

In the case of wax, neither the parameters of a third degree nor those of a lower degree polynomial were significant, which indicates that in this series there is no trend to be removed. In all cases the polynomials were fitted to the untransformed data, since there was little or no connection between mean and standard deviation.

The peaks and troughs of the eleven year moving averages of the residuals of the first five series and of the raw data of wax transports are given in table 1. In the case of herring, the 1743 trough is a rather shallow one and no date is given for the peak between the troughs 1706 and 1743, since there is no single peak year, but rather a plateau between 1720 and 1735. A glance at the table shows that as yet there is not much correspondence between the various time series.

In a second step the sections 1574-1617, 1661-1699 and 1721-1783 of the various time series were subjected to a Box-Jenkins-Analysis. For reasons of economy of time and space only the rough outlines of the results of this analysis can be given here. In the case of rye, wheat and wax, the analysis indicated that the 1574-1617 period was distorted; the structure of this part of the series was considerably less plausible than that of the other parts. This had been expected, since there is general agreement in the literature that it was mainly those goods with a high value per weight unit, particularly the cereals, which were smuggled. And, indeed, when controls were tightened in 1618, registered rye transports increased by 100 % and registered wheat and wax transports by 250 %. Therefore, no importance could be attached to the pre-1618 peaks and troughs of rye, wheat and wax.

The series about transported herring also showed an implausible structure of the form

$$x_t = x_{t-1} - 0.2967\ x_{t-2} + 0.2967\ x_{t-3} + a_t$$

in the 1574-1617 part. This was something of a surprise, since it is agreed in the literature that in the case of bulky goods like herring smuggling played not much of a role. Nevertheless, on the basis of this result I decided also to attach no importance to pre-1618 peaks and troughs of herring transports.

1560 – 1569	1570 – 1579	1580 – 1589	1590 – 1599	1600 – 1609	1610 – 1619	1620 – 1629	1630 – 1639	1640 – 1649	1650 – 1659	1660 – 1669	1670 – 1679	1680 – 1689	1690 – 1699	1700 – 1709	1710 – 1719	1720 – 1729	1730 – 1739	1740 – 1749	1750 – 1759	1760 – 1769	1770 – 1779	1780 – 1789	
					18			48				84				26					70		rye
						22		48				83					30		52				wheat
						21		47				80						46					salt
				07				49				84								64			herring
		89						46				84				28			55				wax
							37				74							47					cloth

table 1

peaks (above) and troughs (below) of the moving averages of the residuals

		80				29				62				05					58				rye
					12	29				62					17			46	59				wheat
	74						32			62				08									salt
	75						31			61				06				43					herring
		80			11					61				01				42		66			wax
			92							69					13					60			cloth

A later investigation turned up the probable cause of the statistical distortion: Until about 1590, a large number of herrings were caught off the Göteborg/Bohüs-Län-area, mainly by Danish fishermen. When this herring was exported into the Baltic, it was not registered in the Sound since Danish goods were exempt from duty. At about 1590, the herring diappeared from the area, opening the Baltic market for Dutch exports of North Sea herring (Tomfohrde 1914, p. 24 and Kranenburg 1946, p. 54). Since Dutch exports were not exempt, registered herring transport roughly quintupled in the following decade.(6)

An intervention analysis of the period 1661-1783 turned up no significant intervention by the non-registration of Swedish goods in any of the six time series. In some cases, however, intervention by the Nordic War was significant.

In a next step, the figures for the years 1618-1657 were left out of the analysis and a polynomial was fitted to the remaining values. The rationale behind this is that since regression analysis is rather vulnerable to distortion by wars and other special influences, the effects of the Thirty Years War and the Danish-Swedish wars of this period on peaks and troughs before and afterwards should be eliminated. In most cases peaks and troughs remained unchanged; in the cases of cloth and salt, however, considerable effects are discernible: Without the period 1618-1657, cloth transports show a trough in 1592 and peaks in 1603 and 1684. In the case of salt the effects are less drastic, here only one additional peak in 1605 results. These two series are the only ones whose pre-1618 structure appears undistorted; the fact that the peaks and troughs of the other series are not affected by the military events of the 1618-1657 period may be due to the fact that their structure is distorted anyway. On the other hand, the particularly strong distortion of cloth transports probably is due to the fact that during the Thirty Years War there was a special conjuncture for textiles.

Table 2 shows the peaks and troughs, which result if the influence of statistical distortions is eliminated. Wartime peaks and troughs are still shown because they were real peaks and troughs; what had to be eliminated is only the influence of the wars on the pre- and post-war periods, which had been induced by polynomial regression.

For the time up to 1618, peaks and troughs are shown only for the undistorted series of cloth and salt. These peaks and troughs approximately coincide. For the time from 1619 onwards, peaks and troughs are given for all series. In the seventeenth century correspondence is very good: The series almost unanimously show troughs about 1630 and 1660 and peaks about 1648 and in the first half of the 1680s. The only exceptions are:

a) a peak of wheat transports in 1622. This is probably due to the fact that in 1621 the truce between Spain and the Netherlands ended and the Dutch, who then dominated the Baltic trade, thus lost their South European market for cereals (Christensen 1934, p. 120). It is to be assumed that this peak is not typical for the development of the economy as a whole.
b) a peak of cloth transports in 1637. This, too, is certainly atypical, since as mentioned before during the Thirty Years War all textiles show a development different from that of all other goods.

In the eighteenth century there is considerably less correspondence among the various peaks and troughs. All series still show a trough during the Nordic War, but individual dates vary from 1701 to 1717. Afterwards, a certain unity still can be found in the next peak at the end of the 1720s, which is shown by three of the series. For the period after 1730, however,

1560 – 1569	1570 – 1579	1580 – 1589	1590 – 1599	1600 – 1609	1610 – 1619	1620 – 1629	1630 – 1639	1640 – 1649	1650 – 1659	1660 – 1669	1670 – 1679	1680 – 1689	1690 – 1699	1700 – 1709	1710 – 1719	1720 – 1729	1730 – 1739	1740 – 1749	1750 – 1759	1760 – 1769	1770 – 1779	1780 – 1789	
								48				84				26					70		rye
						(22)		48				83					30						wheat
				05				47				80						46					salt
								49				84								64			herring
								46				84				28			55				wax
				03			(37)					84						47					cloth

table 2

peaks (above) and troughs (below) of the moving averages of the residuals after elimination of statistical distortions

						29				62				05					58				rye
						29				62					17			46	59				wheat
	74						32			62				08									salt
							31			61				06				43					herring
										61				01				42		66			wax
		80								69					13					60			cloth

the Sound Toll Registers are of little use in determining the state of the economy, since the peaks and troughs of the individual time series are highly divergent.

II. Time series 7: cattle driven through Gottorf and Rendsburg toll stations

During the sixteenth and seventennth century the densely populated Netherlands imported most of the meat consumed there, mainly from the Denmark/Holstein area. Unlike other goods, cattle, which could be driven, were mainly transported by land. In Denmark and Schleswig-Holstein this driving of the cattle was restricted to specific roads, where at certain places a toll was levied on the passing cattle.

The records of some of the toll stations have been at least partly preserved, among them those of the Gottorf and Rendsburg toll stations in southern Schleswig, where with a few minor exceptions (see Wiese 1966, p. 58-63) the routes of all driven cattle converged. About two thirds of the annual cattle export from Denmark and Schleswig was registered here, the remainder being either exported by sea or smuggled past the toll stations (see Wiese 1966, p. 70-77). Since the cattle trade was one of the main international exchanges of the time, these records constitute important historical sources. In 1963, they were evaluated by H. Wiese (Wiese 1966). A table on pages 61 and 62 of his book contains data about the cattle registered annually in Gottorf or Rendsburg. It is this data which I used for my statistical analysis.

The table covers the period 1485-1704. Unfortunately, records and thus the data for many years are lacking for both Gottorf and Rendsburg. For the time prior to 1545, only the records of isolated years have been preserved; thus this data is useless for conjuncture analysis. For the 1545-1704 period, the table contains data for 119 years in the case of Gottorf, and for 84 years in the case of Rendsburg. Some of the figures, however, obviously represent incomplete counts, whereas others are grossly distorted by wartime events.(7) Leaving these values out of the analysis, I had only 113 values for Gottorf and only 79 for Rendsburg.

Had a polynomial been fitted to each of these series seperately, it would have been virtually impossible to determine any peaks and troughs from the moving averages of the residuals, owing to the high number of missing values. I therefore spliced the Rendsburg and the Gottorf data together into a single time series, taking the mean, if for a given year undistorted values were available for both Rendsburg and Gottorf, and otherwise taking the one existing value. The time series obtained contained data for 137 years.

This splicing was possible since with a few exceptions (see Wiese, 1966 p. 58-63) the cattle registered in Gottorf was identical with the cattle afterwards registered in more southerly Rendsburg. Owing to the exeptions, however, the amount of cattle registerd in Gottorf was about five percent higher than that registered in Rendsburg. To compensate, the Rendsburg data was multiplied with 1.05 prior to the splicing of the Rendsburg and Gottorf series.

The statistical analysis was again conducted with the untransformed data, since there was little connection between mean and standard deviation. Since a sizeable share of the exported cattle was not registered at Gottorf or Rendsburg, being either transported by sea or smuggled, it would have been desirable to conduct a Box-Jenkins-Analysis to see whether the structure of the series gives any indications that this constituted a distorting influence. Unfortunately, this is not possible, owing to the numerous missing values; the continuous parts of the series are nowhere long enough to permit a meaningful analysis of this kind.

Fitting a third degree polynomial to the series yielded significant parameters. The polynomial is of the form
$y = -93{,}716{,}712 + 173{,}282.8\ x - 106.62943\ x^2 + 0.021843196\ x^3$;
the moving averages of the residuals show peaks in 1561, 1614 and 1655 and troughs in 1586 and 1668. In addition, there is a trough between the 1614 and 1655 peaks, which, however, can not be dated exactly since a considerable number of values are missing in the 1628-1645 period.

III. time series 8: Venetian production of woolen cloth

This series was taken from an article by Domenico Sella (Sella 1957, p. 28-30). It is based on documents from the Venetian state archives; which kind of documents is not specified in the article. The series covers the period from 1516-1713. It is a continuous series without any missing values, thus a Box-Jenkins-Analysis was possible. This was fortunate for I had to rely on statistical analysis: Nothing is said in the article about non-registration and other kinds of statistical distortions, and I have not yet found other literature on this subject, owing probably to my limited access to Italian sources.

Logs of the raw data were used both for the Box-Jenkins-Analysis and the fitting of a polynomial, since in the case of this series there is a proportional relation between mean and standard deviation. For the Box-Jenkins-Analysis I had to partition the series for two reasons:
a) it is seriously distorted by the Cypric War (1570-1573) and outbreaks of the plague in 1525/26, 1576 and 1628-30, the latter of which was accompanied by a famine (Sella 1957, p. 31).
b) the generating process of the series cannot be considered as one entity; instead, cloth production first grew strongly until about 1570/1580, more or less remained at the level then attained until about 1620, and then began to fall back to the levels of the beginning of the sixteenth century, which had been less than a tenth of that of the 1570-1620 period.

I thus devided the series into three parts:
- 1526-1569, covering the growth period between the 1525 plague and the Cypric War
- 1578-1627, covering the stagnation period between the second and the third of the plagues mentioned
- 1632-1713, covering the decline period after the third plague.

In the case of the periods 1526-1569 and 1578-1627, the Box-Jenkins-Analysis gave no indication of possible distortions. The 1526-1569 period naturally is non-stationary, with the correlogram of the first differences showing a significant negative autocorrelation at lag 1. An estimation of the parameters of the process yielded a value of - 0.3681 for the autoregressive parameter and of 0.0602 for the constant (the low numerical value of the constant is due to the use of logarithms). This translates into a perfectly plausible process of the form
$x_t = 0.6319\ x_{t-1} + 0.3681\ x_{t-2} + 0.0602 + a_t$.

The period 1578-1627 can best be described by a first order moving averages process. This, too, is completely plausible: In this stagnation period there were no systematic tendencies in either direction, thus the effects of random disturbances dominate the structure.

The structure of the 1632-1713 period, however, is not plausible. As was to be expected, this series again is non-stationary; this time, however, each of the correlograms of the first differences shows a single significant negative value at lag 2. This translates into a process of the same kind as the one for herring transported through the Sound in the 1574-1617 period, namely

$x_t = x_{t-1} - \phi\, x_{t-2} + \phi\, x_{t-3} + a_t, \phi > 0,$

which is not a plausible structure. No value should therefore be attached to the peaks and troughs of this period.

The polynomial fitted to the series is of the form

$y = -4{,}875.2345 + 8.7100296\, x - 0.005160609\, x^2 + 0.0000010156964\, x^3.$

The moving averages of the residuals show peaks in 1560, 1603 and 1670 and troughs in 1539, 1575, 1635 and 1687. The 1670 peak and the 1687 trough occured during the decline period, which probably is distorted, and thus can be disregarded. The two troughs in 1575 and 1635 occured during the time of plagues and may to a large extent be due to them, yet this does not automatically imply that it is impossible to draw inferences about the state of the economy from them. Epidemics usually start if a large part of the population is already weakened by malnutrition, which typically will occur during an economic crisis rather than during a time of prosperity. Thus the re-occurence of the plague in intervals of 50 years (1525, 1576, 1628-30) in itself constitutes a possible indicator for a Kondratieff cycle - although it must be cautioned that Sella mentiones the parallel occurence of plague and famine only in one case, that of the plague 1628-30.

IV. time series 9: Lüneburg salina sales data

This series was taken from an article by Harald Witthöft (Witthöft 1976), which contains an abundance of historical statistics about the Lüneburg salina. Most of the time series presented there, however, could not be used for the purposes of this study, because they were too short, because they contained too many missing values or because they covered only part of total sales or production, such as series about sales on specific markets. Only one set of data could be used for conjuncture analysis, namely the data from the Kämmereihauptrechnungen, which are given on p. 89-92 of Witthöft's article. These series contain very few missing values and are sufficiently long. Columns 1 to 9 of these data again only show sales on specific markets or production registered on specific occasions, yet columns 10 and 12, which are the sums of the previous columns, can be regarded as coming close to giving totals, with column 10 permitting conclusions about production and column 12 representing sales (Witthöft 1976, p. 82 onwards).

Unfortunately, the series in column 10 also could not be used: A Box-Jenkins-Analysis showed it to be statistically distorted. The details about this analysis are quite interesting, but cannot be presented here for reasons of time and space. They are, however, given in a forthcoming article, which is scheduled to appear in the December edition of the Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte. The probable reason for the distortion are double counts of part of the salt production.

Thus only one series remained for conjuncture analysis. This series covers the 1682-1800 period, with a number of the values of the first years missing. For my analysis, only the part from 1700 onwards was used, which is continuous. At the end of the series, the figures for the last two years (1799 and 1800) obviously represent incomplete counts and consequently were excluded from the analysis.(8) The 1700-1798 part was subjected to polynomial regression analysis, which was conducted with the untransformed data, since the series shows little connection between mean and standard deviation.

Since the parameters of a third degree polynomial were not significant, a binomial was used, which is of the form

$$-1{,}270{,}453.4 + 1{,}515.0115\ x - 0.44825208\ x^2$$

The moving averages of the residuals show peaks in 1709, 1736 and 1757 and troughs in 1724, 1741 and 1775. I do not tend to attach much importance to the 1709 peak and the 1724 trough. The 1709 peak is mainly due to a few particularly high observations, especially in 1705 and 1711-13. These high observations coincide with sharp decreases of the amount of salt transported through the Öresound (most notably in 1705), which probably are due to the influence of the Nordic War. Since the salt transported through the Sound was largely marine salt, which is known to have been a competitor with salt from the Lüneburg salina (Witthöft 1976, p. 7), it appears propable that the increase of Lüneburg salina sales and thus the 1709 peak is owing to reduced competition due to wartime events, rather than to the influence of conjuncture. With the end of the Nordic War, competition on the Baltic market again increased, and sales of salt from Lüneburg fell, presumably on this account. Thus the 1709 peak and the 1724 trough do not appear to be typical for the state of the general economy at this time.

V. Time series 10 and 11: tallow candles and starch charged with duty, England and Wales

These series were taken from chapter 10 of the Abstract of British Historical Statistics by Mitchell and Deane (Mitchell and Deane 1971). They are based on manuscripted accounts in the Customs and Excise Library, relating to the quantities of the various excisable commodities charged with duty. To the extent that the excise was not evaded, the series constitute records of production (Mitchell and Deane 1971, p. 242).

Chapter 10 contains data about the production of twelve different commodities. For reasons of time only a few of these series could as yet be analysed. It did not appear to be meaningful to select the first six series for this purpose: They cover the production of either raw materials for alcoholic beverages (malt and hops) or of the beverages themselves, and the interpretation of this kind of series is somewhat difficult. (It could, for instance, be argued that a peak in alcohol consumption may well be due to the human problems resulting from an economic crisis. No such argument is possible in connection with the interpretation of a peak of, say, production of starch.) I therefore selected the next three series for my analysis, which cover the production of tallow candles, paper and starch.

The series for tallow candles starts in 1711, the other two series in 1713. All three series extend well into the nineteenth century, yet only the part until 1825 was used, since in 1826 there was a change of the accounting year, with the result that the 1826 figure is for six months only and that the years afterwards are not directly comparable (Mitchell and Deane 1971, p. 262, footnote c).(9)

Unfortunately, all series are somewhat distorted by evasion of duty. According to Mitchell in the case of candles and of starch, both series definitely understate actual production. For candles the degree of understatement appears to have been more or less constant, and the series may thus be taken as an indicator for the development of the entire candle production; yet in the case of starch, illicit manufacture increased in the first decades until about 1740, which partially explains the downward tendency shown by registered production of this time (p. 244). As for paper, Mitchell states that the conditions of its manufacture prevented much evasion of duty, papermakers' equipment being too bulky to be concealed from the excise officials (p. 243). This, however, appearently only refers to the period from 1782 onwards, since footnote c on p. 264 states that it is obvious that before 1782 a great deal of paper had escaped duty. In 1782, the efficiency of collection was improved, resulting in an immediate increase of registered production by some thirty percent.

To get a better idea to which extent the individual series are distorted, Box-Jenkins-Analysis was again used. In the case of candles, logs of the raw data were taken, because there is a proportional relation between mean and standard deviation. No indications for statistical distortions were found in this series.(10) In the case of starch, the situation was somewhat different. For the period 1713-1792, there also is a parallel development of mean and standard deviation, thus again logs of the raw data were used when analysing this part. Here Box-Jenkins-Analysis gave no indications of any distortions; the increase of illicit manufacture in the first decades therefore does not appear to play much of a role. In the 1793-1825 part there is no relation between mean and standard deviation, instead, this part is characterized by a very uneven development with various sharp decreases. It thus was not surprising that the Box-Jenkins-Analysis showed a structure very different from that of the 1713-1792 part and indicative of a MA-process.

Finding the reason for this phenomenon was not particularly difficult: Starch was at this time produced from wheat, the price of which increased considerably in the time following Britain's entry into the war against France (1793). It is easily possible to connect individual, particularly sharp decreases of starch production with corresponding increases in wheat prices, e.g. by comparing the starch series with the price series on p. 487 of Mitchell and Deane's book.(11) Since post-1792 starch production data thus obviously reflects the consequences of wartime events, rather than the general state of the economy, only the 1713-1792 part was used for conjuncture analysis.

In the case of paper, the series also had to be divided into two parts, which had to be analysed separately: 1713-1781, the period before the tightening of the controls, and 1782-1825, the period afterwards. In the 1782-1825 period, there is a clear proposional relation between mean and standard deviation. The structure of this part of the series is completely plausible, as was to be expected from Mitchell's statement. In the 1713-1781 period, however, there is no connection between mean and standard deviation. This came as something of a surprise, since registered paper production almost tripled in this period and since series which show as strong a growth usually exhibit some kind of connection between mean and standard deviation. The most obvious explanation is that the pre-1782 degree of understatement of paper production was not constant, but decreased, perhaps on account of a tightening of control prior to 1782. In this case, the more or less constancy of the standard deviation of registered production probably is due to the evening out of two influences: On the one hand, an increase in the standard deviation of actual production, due to increased production; on the other hand, a decrease of the variance of the share of registered production, due to improved controls.

This explanation is supported by the fact that the 1713-1781 part shows some sudden increases of registered production, which are similiar to the increase from 1781 to 1782. The registered production of 1764, for instance, was more than ten percent higher than that of 1763. This jump, although not quite of the magnitude of that of 1781/82, is nevertheless too high an increase to be attributable to real factors.

Whatever the reasons, Box-Jenkins-Analyis clearly showed this part of the series to have an implausible structure, which again is of the kind $x_t = x_{t-1} - \phi x_{t-2} + 0x_{t-3} + c + a_t$, with c a constant and $\phi > 0$.(12)

It thus must be assumed that the main part of the series is seriously distorted by a changing degree of evasion of duty; consequently, this part could not be used for conjuncture analysis. The remaining part, however, was of little use for the purposes of this study, since it only covers a period in which Kondratieff cycles have already been identified. I therefore refrained from fitting a polynomial to this series.

To the logarithms of the two other series, polynomials were fitted, although in the case of starch only to the 1713-1792 part. For the series about tallow candles a second degree polynomial of the form

$$y = 252.62133 - 0.28846057\,x + 0.000084270345\,x^2$$

was used, since the parameters of a third degree polynomial were not significant. The moving averages of the residuals show peaks in 1723, 1765 and 1803 and troughs in 1745, 1787 and 1814. In the case of the starch series, a third degree polynomial was used, which was of the form

$$y = 78{,}045.36 - 132.75039\,x + 0.075247007\,x^2 - 0.000014213486\,x^3.$$

The moving averages of the residuals show peaks in 1723 and 1759, a major trough in 1741 and a minor one in 1773.

VI. time series 12 to 14: English foreign trade data

These series were taken from the appendix of T.S. Ashton's economic history of eighteenth century England (Ashton 1961, p. 252). Two of the series give, respectively, total English exports (exclusive of specie) and total English imports for the time from 1700 to 1800. The third series may be interpreted as a statistic about the entire English foreign trade; it was calculated by simply taking the sum of the two other series.

Unfortunately these series, like so many others, are somewhat distorted by underreporting due to evasion of duty. It would of course be highly unrealistic to assume that the degree of smuggling remained constant, but for most of the century there does not appear to have been much of a tendency. With Pitt's reform of the customs and the lowering of tariffs between 1784 and 1787 (Plumb 1950, p. 191/192), the incentive for smuggling was reduced, however, and the rise of registered imports and exports in the following years probably can be partially explained by reduced smuggling. Again Box-Jenkins-Analysis was used to get an idea about the impact of these distortions on the series. Since all three series show a proportional relation between mean and standard deviation, logs of the raw data were used throughout. No indications for serious distortions could be found in any of the series.

After this, third degree polynomials were fitted to the series. These polynomials were of the following forms:

for exports:

$$y = -15{,}337.506 + 26.368612\,x - 0.015114292\,x^2 + 0.0000028888306\,x^3$$

for imports:

$$y = -15{,}553.35 + 26.800695\,x - 0.015397142\,x^2 + 0.000002949596\,x^3$$

for the sum of the two:
$y = -15{,}356.037 + 26.428378\,x - 0.015163998\,x^2 + 0.0000029012834\,x^3$

The peaks and throughs of the moving averages of the residuals are:
for exports: a peak in 1763 and troughs in 1723 and 1782
for imports: peaks in 1728 and 1770 and troughs in 1747 and 1781
for the sum of the two: peaks in 1733 and 1767 and troughs in 1707, 1742 and 1782.

In the case of exports, the 1782 trough dwarfs all other residuals, owing to the sharp decline of British exports during the American War of Independence. To eliminate the influence of this factor on the other peaks and troughs, the 1700-1774 part was subjected to a separate regression analysis. Here neither the parameters of a third degree polynomial nor that of a second degree polynomial were significant, thus a linear curve was fitted to the logged data. This curve is of the form

$y = -22.621098 + 0.01431656\,x.$

The moving averages of the residuals now show a peak in 1763 and a trough in 1743.

In the case of imports, the residuals show no predominance of those of the time during the War of Independence, thus it did not appear necessary to subject the 1700-1774 part of this series to a separate analysis. It is not surprising that English exports were much more strongly affected by the American revolution than English imports: Given the enormous pre-1775 trade deficit of the American colonies this was to be expected.

The moving averages of the residuals of the series about the sum of imports and exports, on the other hand, again are dominated by the effects of the War of Independence, owing to the influence of the war on exports. In a separate regression analysis of the 1700-1774 part, again neither the parameters of a third degree polynomial nor that of a second degree polynomial were significant. A linear curve fitted to the logged data is of the form $y = -20.923526 + 0.013669489\,x$, the moving averages of the residuals show peaks in 1727 and 1767 and troughs in 1707 and 1743.

The following table sums up the peaks and troughs for the three series. In the case of exports and of the sum of imports and exports, the peaks and troughs given are that resulting from the separate analysis of the 1700-1774 parts, plus the trough in the time of the American War of Independence identified in the analysis of the entire series. The inclusion of the wartime trough is not an inconsistency: As in the case of the Öresound series, what had to be eliminated is only the trough's influence on previous peaks and troughs, which had been induced by the fitting of the polynomials.

peaks	imports:	1728, 1770
	exports:	1763
	imports + exports:	1727, 1767
troughs	imports:	1707, 1747, 1781
	exports:	1743, 1782
	imports + exports:	1707, 1743, 1782

As is easily seen, peaks and troughs coincide very closely, which is not surprising since there usually is a parallel development of imports and exports.

C. INTERPRETATION OF THE RESULTS

The peaks and troughs of the individual series are summed up in table 3. For series 1 to 6, only the peaks and troughs shown by most series are given, whereas the two peaks due to special influences (1622 for wheat and 1637 for cloth) have been left out. The 1730-1779 area has been shaded to indicate that data are available for this period but that no common peaks and troughs could be identified. In the case of series 12 to 14, the peaks and troughs given are those for the sum of exports and imports.

Agreement among the individual series is surprisingly high, thus it was possible to tentatively identify turning points for the general economy. They are:

- a trough in 1539. It is only one series which goes back as far as this, however.
- a peak 1560/61
- a trough at the end of the 1570s, with the trough of series 7 some years later.
- a peak about 1603/05. Again, the peak of series 7 is some years later, which may be due to the Dutch-Spanish truce in the time between 1609 and 1621. (It can of course not be ruled out that the 1586 trough also is due to the events of the Dutch War of Independence. As a matter of fact one cannot even be sure that 1586 and 1614 actually are, respectively, the trough and the peak year of cattle exports: Next to nothing is known about cattle exported by sea, and given the Dutch naval strength this route may well have been the safer way to export into the Netherlands.)
- a trough about 1630/35. As stated in B II, in the case of series 7 this trough cannot be dated exactly, but also is around this time. Both the trough in the Sound and that of Venetian production of woolen cloth can be connected with non-economic factors (the time of Danish participation in the Thirty Years War and a plague, respectively), but the agreement of the dates is nevertheless notable.
- a peak about 1650, with that of series 7 again slightly later
- a trough in the 1660s, with that of series 7 yet again slightly later than that of the other series. Series 8 shows a peak in this time, but, as said in B III, no value should be attached to its turning points of this period.
- a peak 1680/84. The 1687 trough of series 8 again can be disregarded.
- a trough during the time of the Nordic War, which on account of the conflicting dates in the Sound (see tables 1 and 2) cannot be dated more exactly. The peak of Lüneburg salina sales can be attributed to a special conjuncture, as said in B IV.
- a peak 1723/30. The existence of this peak had already been assumed by Schumpeter, who had deduced it from an increasing number of newly founded English companies until 1719 (Schumpter 1961, vol.1, p. 259/260) and the subsequent events of the South Sea Bubble (Schumpter 1961, vol.1, p. 236). In addition, the bankruptcy of John Law's Mississippi Company, also mentioned by Schumpeter, occured during this time as well (1720).
  Again, the evidence of the turning point of the Lüneburg series can be neglected.
- The series for Lüneburg and the English series all show a trough in the first half of the 1740s.(13) This trough is also shown by three of the Öresound series; two other of the Öresound series, however, show peaks during this time.
- a peak about 1757/65 is shown by the Lüneburg series and all of the English series, but only by one of the Öresound series (herring), whereas four of the Öresound series show troughs during this time. The identification of this peak must therefore be regarded as highly provisional.

1530 - 1539	1540 - 1949	1550 - 1559	1560 - 1569	1570 - 1579	1580 - 1589	1590 - 1599	1600 - 1609	1610 - 1619	1620 - 1629	1630 - 1639	1640 - 1649	1650 - 1659	1660 - 1669	1670 - 1679	1680 - 1689	1690 - 1699	1700 - 1709	1710 - 1719	1720 - 1729	1730 - 1739	1740 - 1749	1750 - 1759	1760 - 1769	1770 - 1779	1780 - 1789	1790 - 1799	1800 - 1809	1810 - 1819	time series *
							03/ 05				about 48				80/ 84				25/ 30										Transports of commodities through the Öresound
			61					14				55																	Cattle passages through Gottorf/ Rendsburg toll stations
			60				03							70															Venetian production of woollen cloth
																	09			36		57							Lüneburg salina sales
																			23				65					03	Production of tallow candles England and Wales
																			23			59							Production of starch, England and Wales
																			27				67						English foreign trade

table 3

peaks (above) and troughs (below) of the moving averages of the residuals, all series

				74/ 80						about 30			61/ 62				during the Nordic War												Transports of commodities through the Öresound
					86					not datable			68																cattle passages through Gottorf/ Rendsburg toll stations
39				75						35				87															Venetian production of woollen cloth
																			24		41			75					Lüneburg salina sales
																					45				87			14	Production of tallow candles England and Wales
																					41			73					Production of starch, England and Wales
																	07				43				82				English foreign trade

In this period no common peaks and troughs could be identified in the Öresound series

- A trough around 1780. This is the first of the turning points which were already identified by N.D. Kondratieff (Kondratieff 1926, p. 589). Kondratieff had dated this trough a few years later, more to the end of the 1780s, and indeed it may well be the case that there was only a minor trough around 1773/75, whereas the recession did not actually bottom out until the end of the 1780s. This definitely is the case with the tallow candles series, and of the two series showing a trough in the first half of the 1770s, the Lüneburg series shows a second trough in 1782, which is almost as deep as that of 1775. As to the starch series, it may simply be too short to show the main trough. (It ends in 1792, which puts the end of the series rather close to a possible trough in the late 1780s, particularly since eleven year moving averages are calculated.)
- The last turning points (a peak in 1803 and a trough in 1814) are given only for the sake of completeness, since it is only the development of the pre-industrial economy which is the subject of this study. They are not the same as the turning points identified by N.D. Kondratieff (Kondratieff 1926, p. 589). An explanation of this would probably be possible, but is beyond the scope of this study.

The distances between individual troughs and individual peaks are:

between peaks:
≈1560 to ≈1605 : about 45 years
≈1605 to ≈1650 : about 45 years
≈1650 to ≈1685 : about 35 years
≈1685 to ≈1725 : about 40 years
≈1725 to ≈1765 : about 40 years,
with the 1765 peak not confirmed by most of the Öresound series.

between troughs:
≈1539 to ≈1580 : about 40 years
≈1580 to 1630/1635 : 50 to 55 years
1630/1635 to ≈1665 : 30 to 35 years
≈1665 to ≈1710 : about 45 years
1710 is of course only a rough approximation, but most of the troughs during the Nordic War lie in the vicinity of this year.
≈1710 to ≈1745 : about 35 years,
with the 1745 trough not confirmed by all of the Öresound series
≈1745 to 1785/1790 : 40 to 45 years,
relying on the jugdment of N.D. Kondratieff and on the evidence of the tallow candles series and the English foreign trade series, rather than that of the Lüneburg and starch production series.

On the average, the distance between succeeding troughs and peaks and thus the duration of individuals swings is 40 to 45 years. The main exceptions to this are the distances between the succeeding troughs 1580, 1630/35 and 1665; the first of these distances is much larger and the second one much shorter than 40 to 45 years. This exception may be due to the aforementioned non-economic factors influencing the 1630/35 trough. The other deviations from the length of 40 to 45 years are minor ones; thus it appears justified to talk about a cycle with a duration of 40 to 45 years.

Considering the fact that the cycles identified by N.D. Kondratieff in the nineteenth and twentieth century have a duration of about 50 to 60 years, this result was somewhat surprising: Contrary to what one would expect, the pace of economic fluctuations in the pre-industrial period appears to have been faster than is the case today. This result, however, is confirmed by the fact that the same phenomenon could also be observed in the shorter business cycles, which had been identified more or less as a by-product of the Box-Jenkins-Analysis.

Of the series analysed, seven contained a cyclical element. In the case of four of these series, the cycle length was either five years (Venetian production of woolen cloth in the 1578-1627 period and starch production in England and Wales in the 1713-1792 period) or six years (transports of wheat and of wax through the Öresound, both in the 1661-1783 period). The cycle length of the other series was:

- seven years for the 1661-1783 period of transports of woolen cloth through the Öresound
- eight years for the 1721-1783 period of transports of salt through the Öresound
- eleven years for the 1721-1783 period of transports of rye through the Öresound.

None of the series contain a cyclical element with a cycle length of nine years, the length of the Juglar cycle of the nineteenth end twentieth century and only one a cyclical element of at least close to nine years, namely salt transports with a cycle length of eight years. Moreover, in the intervention analysis for the entire 1661-1783 period the eight year cycle disappeared and turned into a seven year cycle. It thus appears that in the pre-industrial time the length of the Juglar cycle was only five to six years. (The eleven year swings of rye transport probably each consist of two swings of the five to six year cycle, and the cyclical element of seven years is of course quite close to five to six years.) The observation made in the analysis of the long waves is thus confirmed: Economic cycles did exist in the pre-industrial period, but their length was shorter than that of their nineteenth and twentieth century counterparts. The results of this study therefore can be summed up as follows:

The identification of long economic cycles in the pre-industrial period was possible. The length of these cycles is only 40 to 45 years and thus somewhat shorter than that of the long waves of the nineteenth and twentieth century. A similar phenomenon could be observed in the short business cycles, whose length in the pre-industrial period was only five to six years. Pre-industrial economic fluctuations therefore appear to have been of the same kind as that in the industrial period, but of a shorter duration.

FOOTNOTES

1 This paper is to a large extent based on research done at the University of Cologne under Professor Dr.Dr. Henning. The computations were executed with the Cyber 72 M/Cyber 76 M-combination at the RRZ Köln, using BMDP5R for polynomial regression analysis and either BMDP2T or Ch.R. Nelson's IDENT and ESTIM programs for Box-Jenkins-Analysis.

2 Both Kondratieff and Schumpeter regarded the movement of prices in the Kondratieff cycle as parallel to that of physical quantities. The main proponent of the opposite view is W.W. Rostow; who considers tops in prices as indicative of a trough of general economic activity. A more detailed discussion of this point can be found in van Duijn 1983; chap. V.

3 The main research so for has been done at the University of Trier, but has been largely confined to price series (see e.g. Metz 1983 and the works quoted these).

4 Formally, Sweden did not yield its right of exemption from the Sound toll until the peace of Friedrichsburg in 1720, but since from 1710 onwards Denmark was at war with Sweden, the Swedish exemption practically ended then.

5 In the case of cloth there was the problem that it had been registerd by the customs officers in three different units of measurement: in pieces, in packs and in "Ellen" (a measurement of length). A conversion from one unit into another for the purpose of summing up was obviously impossible. The number of transported packs was small, however, and annual figures for transported Ellen are given in the tables only for the time until 1595, consequently I confined my analysis to cloth registered in pieces.
A similiar problem posed itself in the case of wax, which in the first decades was registered both in shippounds and in pieces. Only the data about wax registered in shippounds were used in this study, since the amount of wax registered in pieces was quite small and is moreover given in the tables only for the time until 1685.

6 About 1750, herring returned to the Bohus-län area. This, however, did not result in a decrease of registered herring transports, since the area had by then become Swedish in the peaces of Rothschild and Seeland (1658 resp. 1660) and since Swedish goods after 1720 were no longer exempt from duty.
As a matter of fact, the return of the herring actually resulted in a sharp increase of herring transports: Prior to 1750, both the size of the Dutch herring fishing fleet and its annual catch had declined considerably. The fishing fleets of other nations, particularly England, had increased, but the absolute magnitude of this increase was below that of the decrease of the Dutch fleet, consequently there had been an overall decline of the number of herring caught (Kranenburg 1946, p. 176). This decline was now offset by Swedish catches of herring, which to a large extent were exported into the Baltic (Krünitz Enciclopädie, vol. 150, 1829, p. 402).
In a sense, this effect of the return of the herring also constitutes a distortion affecting the peaks and troughs of the series. Nevertheless these peaks and troughs cannot be ignored, since the sudden increase is not due to statistical, but to real influences. (And, of course, the higher supply of herring cannot alone explain the increase of transported herring; there also must have been a growing market.) The shalllowness of the 1743 trough, however, is easily attributable to the combined effects of the increase a few years later and the calculation of moving averages; therefore it does not imply that the 1743 trough was unimportant.

7 They are: 1644, 1645, 1658-1660 and 1689 for the Gottorf series and 1618, 1658-1660 and 1666 for the Rendsburg series.

8 The remaining values are not entirely undistorted, however. The series is derived from tax records, and after 1720 one of these taxes was no longer based on actual sales; instead, a fixed amount was collected annually. From 1746 onwards the same applied for a second of these taxes as well (Witthöft 1976, p. 82). Despite this, Box-Jenkins-Analysis gave no indications that structure of the series is distorted, thus it can be assumed that what distortion there is, does not invalidate the series for the purposes of this study.

9 In the case of paper, Mitchell and Deane give two series, one for England and Wales and one for Scotland, the latter starting in 1737. Adding up the two series would have resulted in a break in 1737, thus

they had to be analysed separately. For reasons of time I confined myself to the analysis of the series for England and Wales, since the amounts of paper produced in Scotland constituted only a small fraction of the English and Welsh paper production.

10 In this case, no single analysis could be conducted for the entire series, since its first half (until about 1755) is stationary and its second half is non-stationary. Instead, a separate analysis was performed for each of the parts and a third analysis was conducted to check for a possible structural break in the 1736-1775 transition period. None of the analysses gave any indications for distortions.

11 In doing so it must be considered that for the price series the year given is the calendar year, whereas for starch production it is the accounting year ending July 5th.

12 The repeated occurence of this structure in distorted series is notable. To my knowledge, there exists as yet no statistical explanation for this phenomenon, but it appears worthy of investigation.

13 The 1736 peak of the Lüneburg series, which is not a high one anyway, can of course be easily explained by the fact that between one trough due to special circumstances and one trough due to the development of the general economy there has to be a peak somewhere.

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